Missouri Department of Natural Resources

Total Maximum Daily Load Information Sheet

Big River and Flat River Creek

Water Body Segment at a Glance:


State Map Showing Location of Watershed

County: St. Francois/Jefferson
Nearby Cities: Leadwood to Eureka
Length of impairment: Big River - 93 miles
Water Body IDs: 2074 and 2080
Flat River Creek – 5 miles
Water Body ID: 2168
Pollutants: Lead, Nonvolatile Suspended Solids (NVSS)
Source: Old Lead Belt Abandoned Mine Land

Other Pollutant: Zinc (Flat River Creek only)
Source: Elvins tailings pile

Note: See also the Information Sheet for cadmium and zinc, added to the 2008 303(d) list for all segments.

TMDL Priority Ranking: TMDL Approved 2010

Description of the Problem

Beneficial uses of both Big River and Flat River Creek:

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Human Health Protection (Fish Consumption)
- Whole Body Contact Recreation

Uses that are impaired:

- Protection of Warm Water Aquatic Life
- Human Health Protection (Fish Consumption)

Standards that apply:

- Missouri Water Quality Standards for metals found in 10 CSR 20-7.031(4)(B)1 state:
  - Water contaminants shall not cause the criteria in Tables A and B to be exceeded. Concentrations of these substances in bottom sediments or waters shall not harm benthic organisms and shall not accumulate through the food chain in harmful concentrations, nor shall state and federal maximum fish tissue levels for fish consumption be exceeded.
  - Current lead and zinc standards (Table A) for the protection of aquatic life use are expressed in dissolved form. They are hardness dependent and are calculated from these formulas:

Dissolved Lead

Chronic = $e^{(1.273*\ln(\text{hardness})-4.70479)}*(1.46203-(\ln(\text{hardness})*0.145712))$ = μg/L[1]

Acute = $e^{(1.273*\ln(\text{hardness})-1.460448)}*(1.46203-(\ln(\text{hardness})*0.145712))$ = μg/L

Dissolved Zinc

Chronic = $e^{(0.8473*\ln(\text{hardness})+0.785)} * 0.978$ = μg/L

Acute = $e^{(0.8473*\ln(\text{hardness})+0.8842)} * 0.986$ = μg/L

To arrive at a hardness for the Big River watershed, the 25th percentile of 262 hardness records taken within the basin. That figure is 200 mg/L. Using 200 mg/L hardness, the following criteria were calculated:

Lead: 136 and 5 μg/L for acute and chronic respectively.
Zinc: 211 and 193 μg/L for acute and chronic respectively.

- Standards for nonvolatile suspended solids (NVSS) can be found in the general criteria section of the WQS, 10 CSR 20-7.031(3)(A), (C) and (G) where it states:
  - Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses.
    - Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses.
    - Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.

Background Information and Water Quality Data:

Flat River Creek is a tributary to Big River. It is impaired by three sources:

- Erosion of lead tailings from the Federal tailings pond (St. Joe State Park)
- Erosion of chat from the National Chat pile which adjoins the Flat River Glass Company
- Erosion of chat and discharge of dissolved zinc from the Elvins chat pile

Erosion of chat directly from the Leadwood and Desloge chat piles, as well as chat entering from Flat River Creek, impairs Big River. Tailings and chat are the part of washed or milled mineral ore considered too poor to be treated further. In other words, they are the ground-up rock (predominantly sand-sized pieces of limestone) left over after extracting the desired minerals (in this case lead and zinc). Erosion has resulted in a large amount of chat and tailings being deposited in pools within these streams. These sediments (or nonvolatile suspended solids) reduce the aquatic habitat quality by smothering natural substrates (materials in the streambed). Aquatic invertebrate animals (water insects, mussels and crayfish) and fish eggs are also smothered.

Fish and other aquatic life have accumulated elevated levels of lead in their bodies due to dissolved lead draining from the old tailings. Ninety-three miles of Big River, from Leadwood to the river's mouth, and the lower six miles of Flat River Creek presently are under a Missouri Department of Health and Senior Services (DHSS) advisory recommending no consumption of sunfish, carp or suckers due to lead contamination of these fish.

[1] μg/L = micrograms per liter, or parts per billion; mg/L = milligrams per liter, or parts per million.

In humans, lead primarily affects the nervous system, blood cells, and processes for the metabolism of Vitamin D and calcium. Lead can affect the developing fetus during pregnancy and cause lower intelligence scores, poor attention levels; hearing, speech and language problems; reading disabilities; reduced motor skills and poor hand-eye coordination. The Agency for Toxic Substances and Disease Register considers blood lead levels over 10 micrograms per deciliter (µg/dL) as toxic. According to the Missouri Department of Health and Senior Services, 11 percent of the children in St. Francois County tested for blood lead levels actually have lead poisoning. Nationwide, the average for lead contamination in children is less than three percent. It is not known how much of the lead contamination in humans in this area is due to consumption of fish as opposed to other possible sources of lead such as eating locally grown vegetables, inhalation of airborne lead or ingestion of lead in paint or in the soil.

Average levels of heavy metals upstream and downstream of the tailings areas are shown in Table 1 below for Flat River Creek and Big River, as are the Probable Effect Levels for these metals in sediments. These probable effect levels are the concentrations of metal in sediment that are likely to cause impairment to the aquatic biological community. These data show that levels of metals in stream sediments are higher downstream of the mining area than upstream and that sediment toxicity due to heavy metals may be occurring throughout the area.

Contamination of stream sediments has led to the contamination of fish and other aquatic life. Table 2 below shows average levels of lead in fish in Big River. There is no state or national standard for allowable lead in food, but the World Health Organization (WHO) uses a standard of 0.3 mg/Kg. This level is exceeded in some kinds of fish in Big River downstream of the tailings area.

The TMDL for Big River, Flat River Creek and Shaw Branch was approved by the U.S. Environmental Protection Agency on March 24, 2010.

Table 1

Entries in **bold** type exceed water quality standards.

Mean Levels of Heavy Metals in the Sediments of Flat River Creek and Big River upstream and downstream of the Old Lead Belt Tailings Area (milligram/kilogram or mg/Kg) and Number of Samples Comprising the Average (#)					
Location	**Cadmium**	**Copper**	**Lead**	**Nickel**	**Zinc**
Flat River Creek at Derby (upstream)	1.97 (4)	32 (5)	**545** (7)	29.5 (2)	165 (7)
Flat River Creek below National Chat pile (downstream)	**12.5** (7)	**231** (6)	**4,084** (7)	**68.5** (2)	**1,078** (7)
Big River at Irondale (upstream)	0.58 (10)	27.4 (5)	**286** (10)	22.5 (2)	69.6 (10)
Big River below Desloge tailings pile (downstream)	**86.6** (5)	31.2 (3)	**3,311** (5)	(0)	**4,104** (5)
Probable Effect Level of Metal in Sediment	*3.2*	*100*	*82*	*33*	*540*

Source: U.S. Geological Survey, University of Missouri Rolla, Department of Natural Resources, and Newfields Inc.

Table 2

Mean Concentrations of Lead in Fillets of Fish from Three Locations on Big River (mg/Kg) and Number of Samples Comprising the Mean (#)				
Location	Carp	Suckers	Bass	Sunfish
Big River at Irondale (upstream of tailings area)		0.041 (21)	0.036 (17)	0.019 (13)
Big River near Desloge (25 miles downstream of tailings area)	0.127 (3)	**0.349** (12)	0.163 (3)	**0.543** (10)
Big River at House Springs (55 miles downstream of tailings)		0.142 (22)	0.088 (14)	0.134 (10)

Source: University of Missouri Rolla, Missouri Department of Conservation, Department of Natural Resources and U.S. Environmental Protection Agency

In addition to lead contamination of sediment and fish, water draining from the Elvins chat pile in Elvins has caused high levels of dissolved zinc in Flat River Creek. During low flow periods, there is enough zinc in the drainage from the chat pile to cause levels of zinc in Flat River Creek to exceed state water quality standards for toxicity to aquatic life (See Table 3). Because compounds of zinc are generally soluble in neutral and acidic solution, zinc is readily transported in most natural waters and is one of the most mobile of the heavy metals. Hardness, dissolved oxygen, temperature and synergistic effects (more than the sum of the individual components) with other compounds all affect the toxicity of zinc to aquatic life[2]. Zinc is an essential nutrient to aquatic and terrestrial organisms, but in excess can be highly toxic and has the tendency to bioaccumulate (build up in organisms) in the environment. A number of behavioral and physiological effects have been reported when test organisms are exposed to increased zinc levels. Behavioral responses in fish include avoidance and changes in feeding rate and movement patterns. Physiological changes in fish include increased ventilation rates, frequency of coughing and a decrease in oxygen utilization.[3]

Table 3. Mean Concentrations of Dissolved Zinc in Flat River Creek
(Number of Samples)

Location	Dissolved Zinc (μg/L)
Flat River Creek at Derby, upstream of tailings area	28.7 (19)
Flat River Creek at Main Street in Flat River	**468.8** (32)

Note: Using a hardness of 200 mg/L (see page 2), the chronic standard for zinc is 193 μg/L.

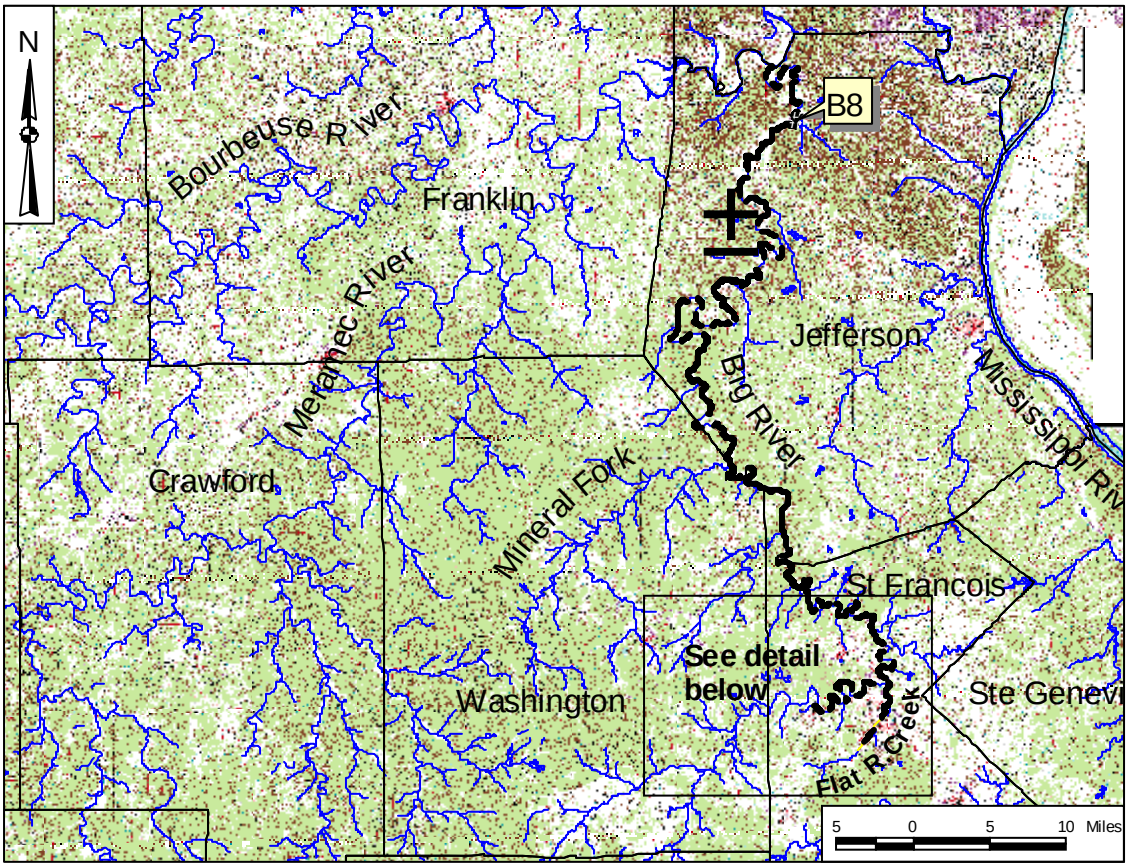
Studies on Flat River Creek and Big River conducted by the department from 2001 to 2003 found a higher percentage of sand-sized or finer sediments deposited in the streambed within the tailings area and a reduced diversity of aquatic macroinvertebrates within and downstream of the tailings area. Fine sediment deposition rates on the portion of Big River upstream of the tailings area

[2] Upper Sacramento River TMDL for Metals. California Environmental Protection Agency, 9/25/01. www.waterboards.ca.gov/centralvalley/programs/tmdl/TMDL%20Final%20Report_2002Apr.pdf
[3] Red Clay Creek TMDL, Delaware Natural Resources and Environmental Control, 8/1/99. www.dnrec.state.de.us/dnrec2000/library/water/rcproreg.pdf

averaged 12 percent and within and downstream of the tailings areas 26 to 64 percent. On the portion of Flat River Creek upstream of the tailings area, stream substrate averaged 18 to 23 percent fine sediments and within and downstream of the tailings area 37 to 77 percent.

Maps and data on the following pages. For related information, see the Shaw Branch Information Sheet. Shaw Branch is a tributary to Flat River Creek.

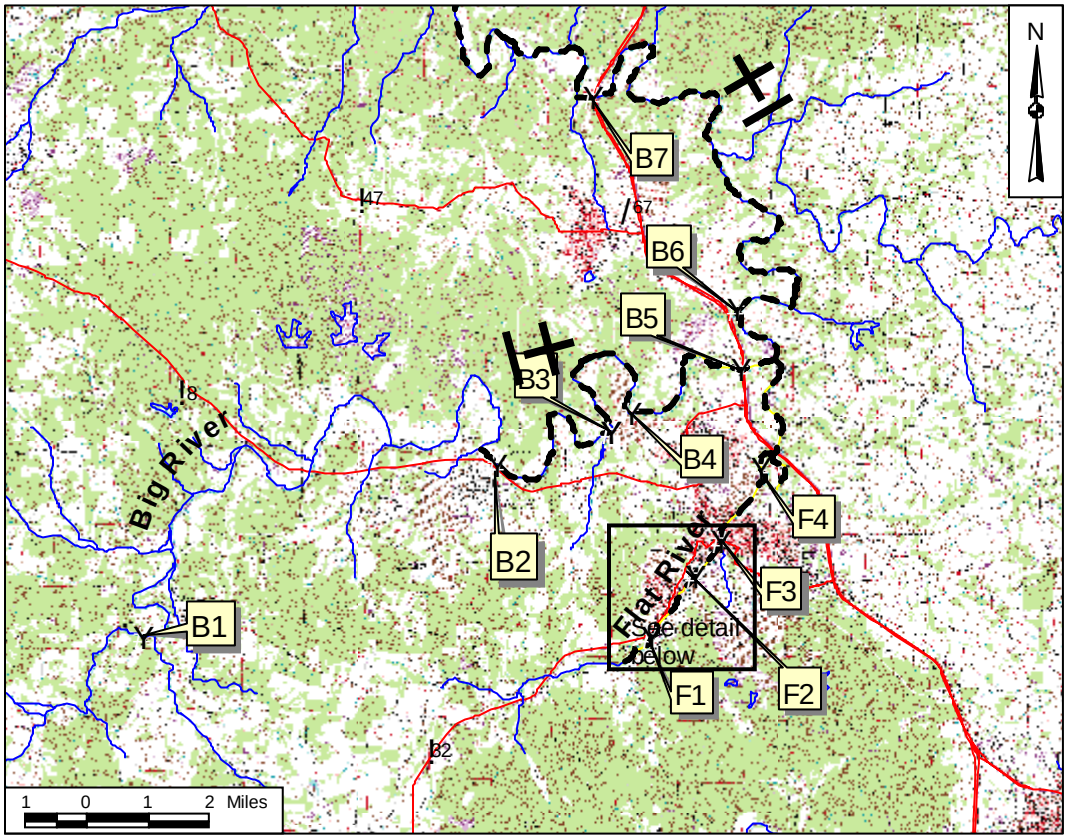
Impaired Segments of Flat River Creek and Big River in St. Francois and Jefferson Counties, Missouri, and Sampling Site



Impaired segment → Direction of flow

Sample Site
B8 – Big River at House Springs Access

Detail of Sampling Sites for Big River and Flat River Creek



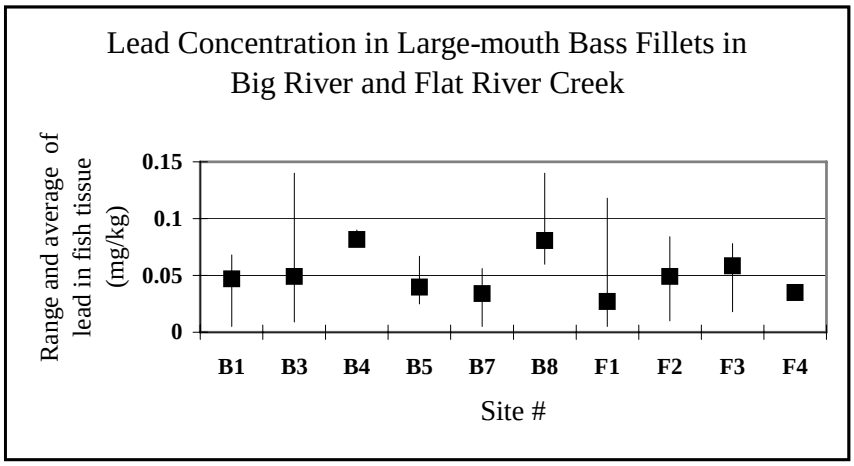
Impaired segment Direction of flow

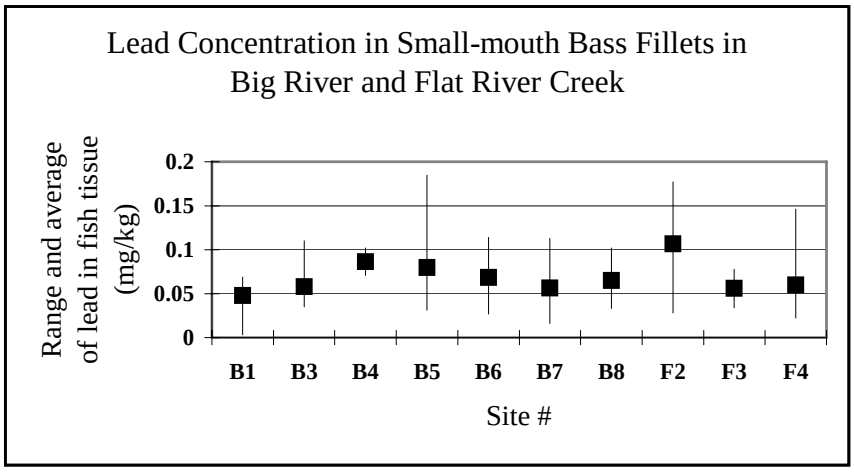
Sample Site Index

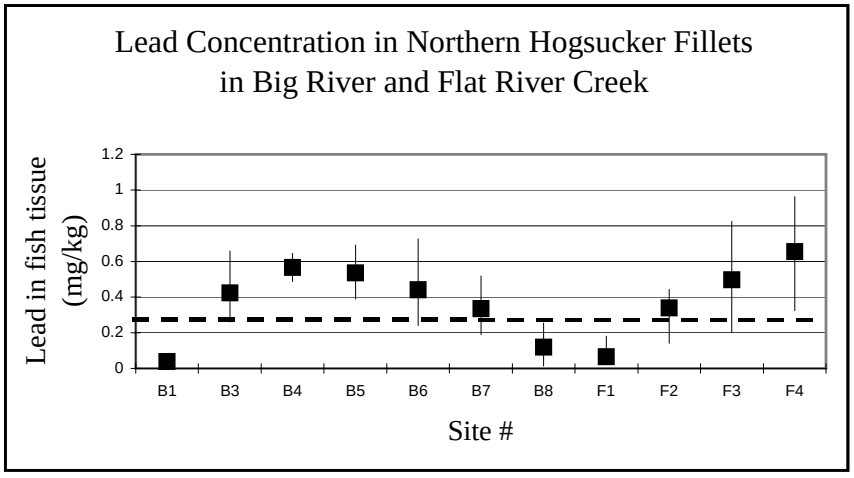
B1 – Big River at Irondale
B2 – Big River at Leadwood access
B3 – Big River at Bone Hole
B4 – Big River at East end of Desloge tailing pile
B5 – Big River below Desloge
B6 – Big River 1.2 miles below Flat River Creek
B7 – Big River 11.7 miles below Flat River Creek

F1 – Flat River Creek at Derby
F2 – Flat River Creek just below Elvins tailing pile tributary
F3 – Flat River Creek at Main Street, town of Flat River
F4 – Flat River Creek below National chat pile

Detail of Flat River Creek on page 10.

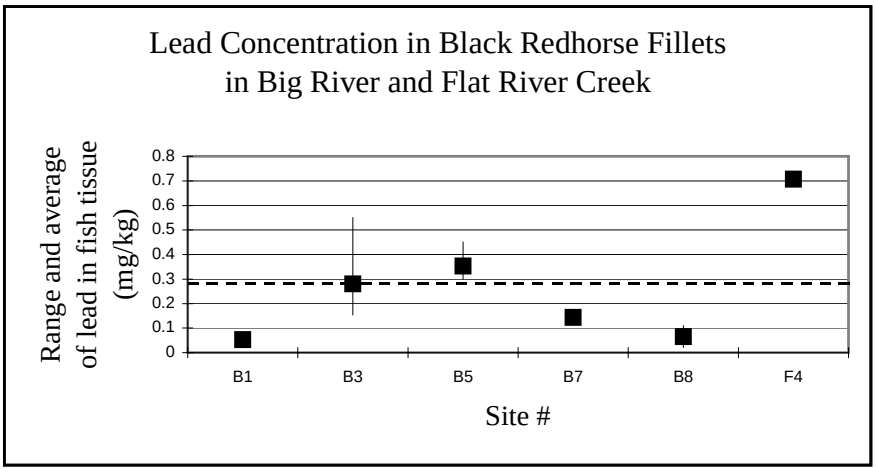


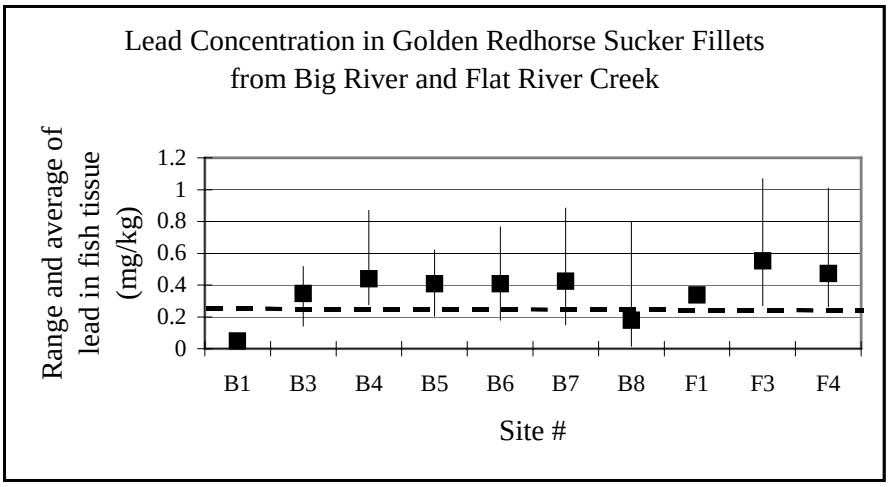


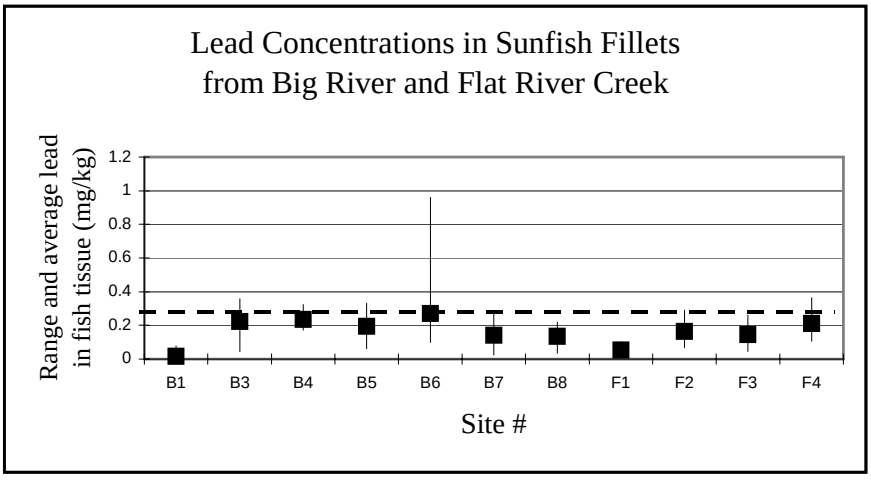


Dashed line equals 0.3 mg/kg, the maximum recommended lead concentration in fish to be consumed (World Health Organization).

Source: Dr. Gary Patterson, University of Missouri, Rolla







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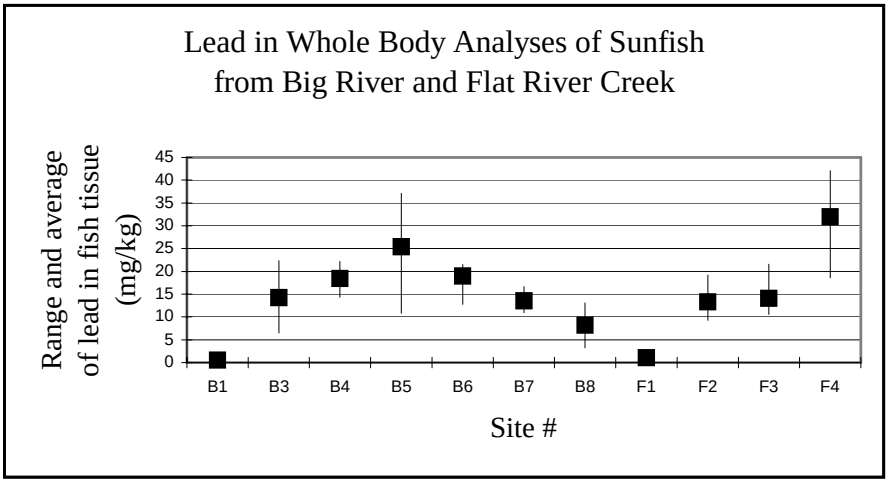
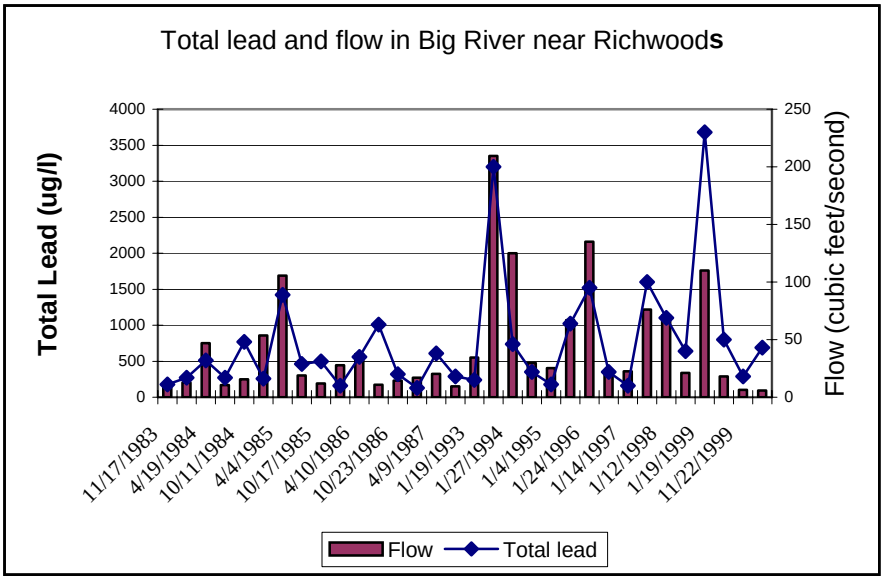
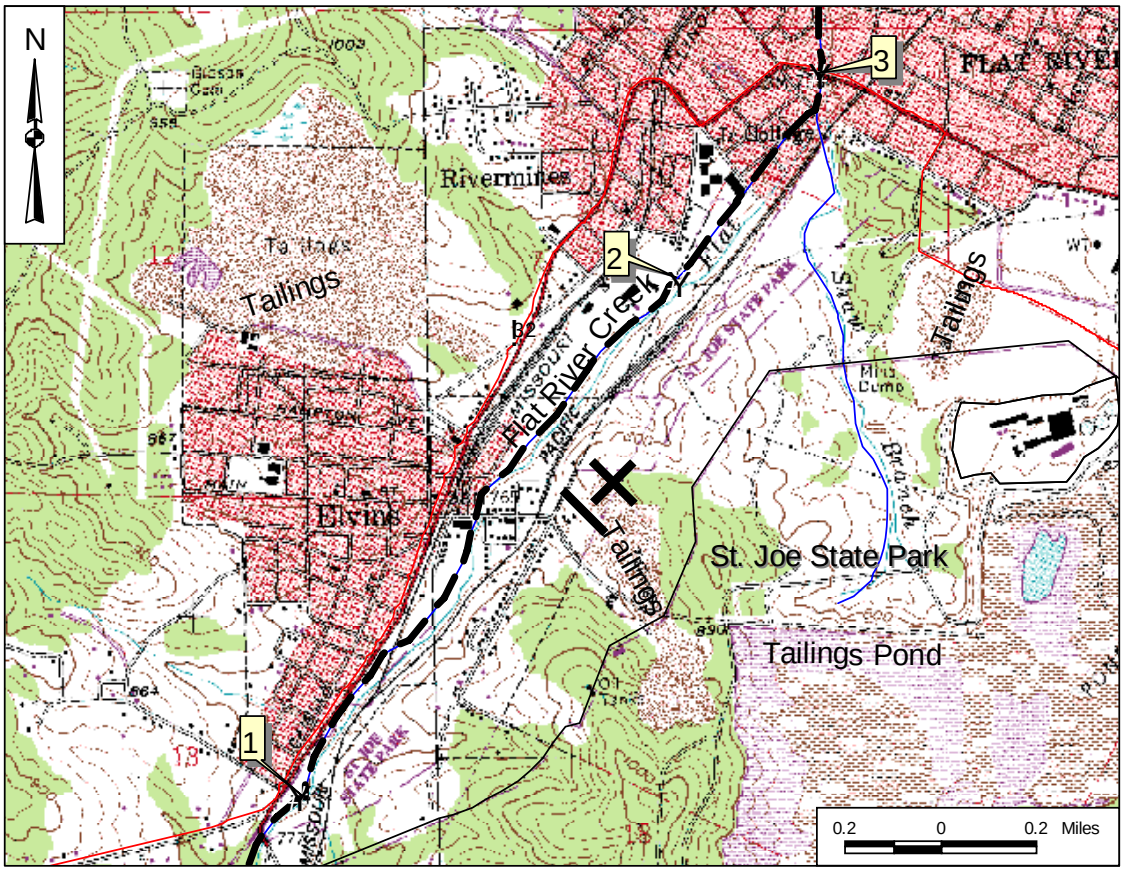




Source: Dr. Gary Patterson, University of Missouri, Rolla

For additional and more recent data, see Appendices F-H in the Big River TMDL (Pages 43-70) at http://www.dnr.mo.gov/env/wpp/tmdl/2074-2080-2168-2170-big-r-tmdl.pdf

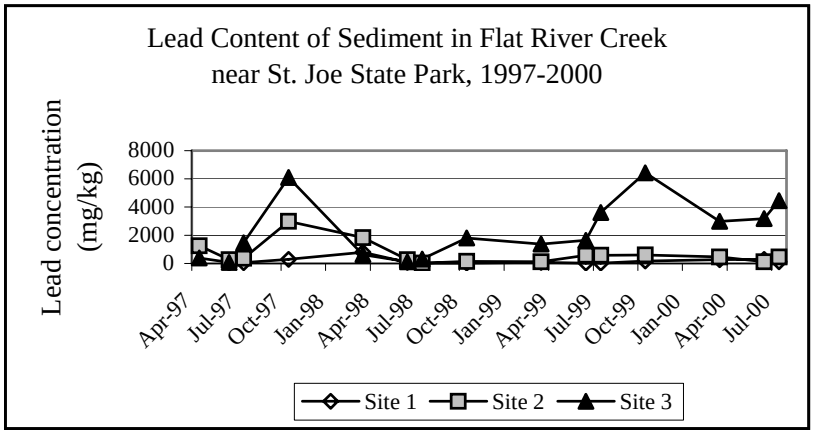
Detail of Flat River Creek

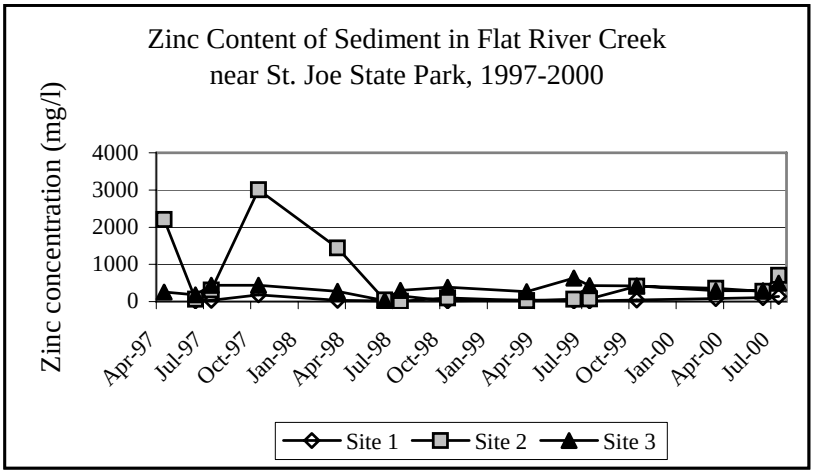


Impaired Segment Direction of flow

Site Index

1 – Flat River Creek at Hwy B
2 – Flat River Creek at Rivermines
3 – Flat River Creek at Main Street, Flat River





Source: Missouri Department of Natural Resources, Division of State Parks

For more information call or write:
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P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-1300 office
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Program Home Page: www.dnr.mo.gov/env/wpp/index.html